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Research Paper

Timber Line Delineations Using NDVI Techniques in the Gori Ganga Watershed of Kumaun Himalaya, Uttarakhand

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ABSTRACT
Present research paper is an attempt to delineations the timber line by using Normalized Difference Vegetation Index (NDVI) in the Gori Ganga watershed, Kumaun Himalaya, Uttarakhand (India). The objective of the present study is delineation of vegetation lines of the Gori Ganga watershed in time space. For the study of detect timber line used of Landsat-5, 8 and Cartosat-1 satellite imageries of three different time periods like Landsat-5 Thematic Mapper (TM) of 1990, Landsat-5 (TM) of 1999 and Landsat-8 Operational Land Imager and Thermal Infrared Sensor (OLI and TIRS) of 2016 and Cartosat-1 of 2008. Geographical distribution of timber line average height reveals that in 1990 was about 3516.11 m (± 369 m) which varies between 1729 m to 4560 m, in 1999 was about 3680.69 m (± 362 m) which varies between 2654 m to 6093 m and in 2016 was about 4060.58 m (± 619 m) which varies between 3125 m to 5185 m.
KEY WORDS: *NDVI Techniques, Timber line, Remote Sensing and GIS*

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I. INTRODUCTION

Ecosystem provides various forms of services through payment mechanism which contributes surplus money to national income and supports to improve the local livelihoods (Khanal et al., 2014). The ecosystem service provides several goods and services to human via ecosystem function (Khadka and Shrivastav, 2015). These services are directly or indirectly linked by human for life support from its function (Zhao et al., 2017). Due to rapidly growing demands of the goods and services it affects the ecosystem services to local livelihoods and community at the regional scales in recent time (Pradhan et al., 2010). In a broad sense, the alpine timberlines represent the upper limit of forest on a mountain (Wardle, 1974, 1993 and 1998). The upper limit of natural forests with a steep gradient and increasing stand fragmentation and stuntedness is sometimes called the tree line ecotone (Korner, 1998). Korner (1998) defines a tree as an upright woody plant with a dominant above-ground stem that reaches a height of at least 3 meters, with its crown closely coupled to prevailing atmospheric conditions. By Shekhar et al., 2010, an increase in the annual average temperature of 2^0C has already been recorded from different parts of Western Himalaya, which is based on statistics of data collected from different metrological stations situated in Jammu and Kashmir (Drass, Gulmarg) and Himanchal Pradesh (Manali, Solang) over the period of 24 years between 1984 to 2008. In another study on aerosol product of MODIS satellite data found that annual mean tropospheric warming has increased by 1^0C over western Himalaya in between 1997 to 2007 (Gautam et al., 2009). Several authors have studied the timberline vegetation of Western Himalaya but all these studies deal with the structure and composition of vegetation community in general and not specific to the altitudinal limit and phenology of timberline vegetation (Kalakoti et al. 1986; Rawal and Pangtey, 1994; Rawal and Dhar, 1997; Maikhuri et al. 1998; Adhikari, 2004). In western Himalaya, Timber line ranges between 3200 to 3800m while in some places it is recorded at 4150 m (Adhikari, 2004). Literature review suggests that timberline lies between 3700 to 3900 m in upper Yamuna (Puri et al., 1989) and 3600-3900 m at Gangotri (Dudgeon and Kenoyer, 1925; Adhikari and Rawat, 2004) and Tons (Gupta and Singh, 1962).
The integrated Geographical Information System (GIS) and Remote Sensing (RS) system application found to be effective tools in understanding the rate of land use land cover change with time and space (Baidya et al., 2009). GIS and remote sensing can answer the various questions about Land Use Land Cover (LULC) and impact on animal kind, humankind, ecology and environment (Rindfuss et al., 2004).

II. METHODOLOGY

The present study works out the analysis of timber line using remote sensing data. Remote sensing data are extremely valuable to examine the dynamics of timber to determine timber line. To determine timber line Landsat-5 (TM) for the year 1990 and 1999, Landsat-8 (OLI and TIRS) for the year 2016 and Cartosat-1 Satellite images for the year 2008 were used from www.USGS.com, website and Global Land Cover Facility (GLCF). For all three years cloudless images of selected for the month of November. The study area, i.e., Gori Ganga watershed was clipped using its shape file from satellite images and the image was given the base map coordinates, i.e., UTM projection, 44 N zone for the purpose to identify the study area in the images. For the NDVI raster data of the 1990, 1999, and 2016 was calculated in Arc GIS 10.2.2 software using the equation Normalized Difference Vegetation Index (NDVI) = NIR-Red/NIR+Red. Where NIR (Near Infrared) = Band 4 (Landsat-5) and Band 5 (Landsat-8), RED= Band 3 (Landsat-5) and Band 4 (Landsat-8).

III. LOCATION AND EXTENT

The study area, viz., the Gori Ganga watershed (Kumaun Himalaya) extends between $29^0$45'0''N to $30^0$35'47''N latitudes and $79^0$59'33''E to $80^0$29'25''E longitude, and encompasses an area of 2191.93 km^2 in Figure 1. Figure 2 depicts the altitudinal distribution of the Gori Ganga watershed which is varies between 626 m and 6639 m. The Gori Ganga watershed has 168 villages and total population is about 40616 (2011).

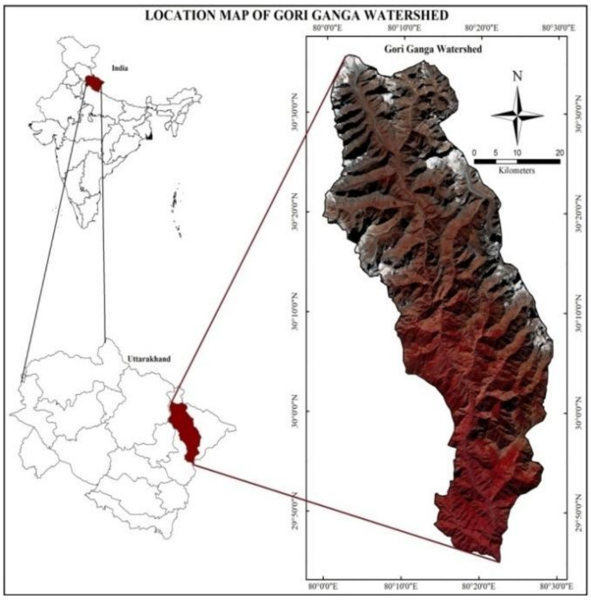

Figure 1: Geographical location and extension of the study area Viz. Gori Ganga watershed, Kumaun Himalaya, Uttarakhand.

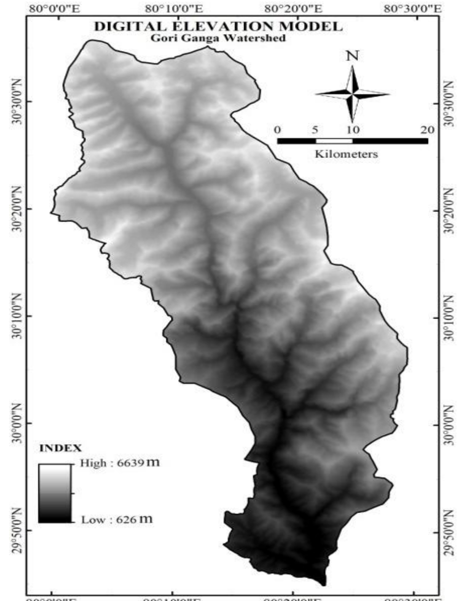

Figure 2: Digital Elevation Model (DEM) of the Gori Ganga watershed.

IV. RESULT AND DISCUSSION

The results obtained through the analysis of NDVI imagery are diagrammatically illustrated in Figure 3. Figure 4 depicts Timber line height frequency curve in 1990 to 2016 which is registered in Table 1. While Figure 5 depicts average altitude of timber line and Figure 6 depicts geographical distribution of average timber line heights in 1990, 1999 and 2016 in the Gori Ganga watershed which is registered in Table 2. Plates 1 and Plate 2 are presenting timber lines in the different alpine regions of the study area. A brief account of these results it's discussed in the following paragraphs.

V. NORMALIZED DIFFERENCE VEGETATION INDEX (NDVI)

Holme et al., 1987 present's healthy vegetation absorbs most of the visible light that falls on it and reflects a large portion of the near-infrared light. Unhealthy vegetation reflects more visible light and less near-infrared light and bare soils on the other hand reflect moderately in both the red and infrared portion of the electromagnetic spectrum. NDVI is calculated as a ratio difference between measured canopy reflectance in the red and near infrared bands respectively (Nageswara et al., 2005). The NDVI is a numerical indicator that uses the visible and near-infrared bands of the electromagnetic spectrum and is adopted to analyze remote sensing measurements and assess whether the target being observed contains live green vegetation or not.

NDVI has found a wide application in vegetative studies as it has been used to estimate crop yields, pasture performance and rangeland carrying capacities among others. It is often directly related to other ground parameters such as percent of ground cover, photosynthetic activity of the plant, surface water, leaf area index and the amount of biomass. Since we know the behavior of plants across the electromagnetic spectrum, we can derive NDVI information by focusing on the satellite bands that are most sensitive to vegetation information (Near-Infrared and Red). Theoretically, NDVI values are represented as a ratio ranging in value from -1 to 1 but in practice extreme negative values represent water, values around zero represent bare soil and values over 6 represent dense green vegetation. Figure 3 depicts geographical distribution of NDVI values (>0.2) in the Gori Ganga watershed in 1990, 1999 and 2016.

VI. METHOD OF TIMBER LINE HEIGHT DELINEATION

Timber line height estimation is an important aspect in the timber line mapping. It reveals that what is the current status of timber line in the study area? The threshold value of NDVI range >0.4 are used for timber line map out, respectively (www.earthobservatory.nasa.gov). After displaying the NDVI imagery on the screen of Arc map, the upper limit of timber cover in the watershed area was digitized for both years. In order to draw timber line, a shape file was created in Arc GIS software in Arc-catalogue and timber line has been digitized for the year 1990, 1999, and 2016. To estimate timber line height, the timber line of both the years were overlaid on the DEM data and then a point shape file has been created in arc-catalogue and keeping the snapping mode on, the digitization was done, over the timber line of both year and then the digitized points were masked by the mask function from DEM data, so, that each point bear some height and then those points were exported into the Microsoft excel sheet and the average height have been estimated. Table 1 and Figure 4 depict the timberline height frequency rate and curve in the Gori Ganga watershed. The methodology is as, firstly took Landsat-5 (TM) and 8 (OLI and TIRS) imageries 1990, 1999 and 2016 and demarcated the timber line on these images. Obtaining value from different elevation point for timber line average height of different years was worked out as presented in Table 2 and Figure 5 which is geographically presented in Figure 6.

6.1 Timber Line 1990

To determine the average height of the timber line for the year 1990. 19433 height points were taken from DEM and they were summarized and present in Table 1 and Figure 4 (A). The frequency curve of these height points reveals that the average height of timber line in 1990 was about 3516.11 m (sd ± 369 m) which varies between 1729 m to 4560 m in the Gori Ganga watershed presents in Table 2 and Figure 5. Figure 6 (A) depicts the special location of timber line in the Gori Ganga watershed in 1990.

6.2 Timber Line 1999

To determine the average height of the timber line for the year 1999. 4289 height points were taken from DEM and they were summarized and present in Table 1 and Figure 4 (B). The frequency curve of these height points reveals that the average height of timber line in 1999 was about 3680.69 m (sd ± 362 m) which varies between 2654 m to 6093 m in the Gori Ganga watershed presents in Table 2 and Figure 5. Figure 6 (B) depicts the special location of timber line in the Gori Ganga watershed in 1999.

6.3 Timber Line 2016

To determine the average height of the timber line for the year 2016. 21702 height points were taken from DEM and they were summarized and present in Table 1 and Figure 4 (C). The frequency curve of these height points reveals that the average height of timber line in 2016 was about 4060.58 m (sd ± 619 m) which varies between 3125 m to 5185 m in the Gori Ganga Watershed presents in Table 2 and Figure 5. Figure 6 (C) depicts the special location of timber line in the Gori Ganga watershed in 2016.

Table 1: Timber line height frequency rate in 1990, 1999 and 2016 in the Gori Ganga watershed *(based on Cartosat-1, Satellite image).*

S. N.	Height group	Frequency of height points			S. N.	Height group	Frequency of height points		
		1990	1999	2016			1990	1999	2016
1	1500-2000	46	0	0	7	4500-5000	7	443	7006
2	2000-2500	181	0	0	8	5000-5500	0	11	5900
3	2500-3000	863	0	167	9	5500-6000	0	0	1854
4	3000-3500	5312	337	703	10	6000-6500	0	0	39
5	3500-4000	10669	1758	2125	Total		19433	4289	21702
6	4000-4500	2355	1740	3908					

Table 2: Average height of timber line in 1990, 1999 and 2016 in Gori Ganga watershed *(based on Cartosat-1, Satellite image).*

Year	Average timber height (m)	Standard deviation (m)	Minimum height (m)	Maximum height (m)
1990	3516.11	± 369	1729	4560
1999	3680.69	± 362	2654	6093
2016	4060.58	± 619	3125	5185

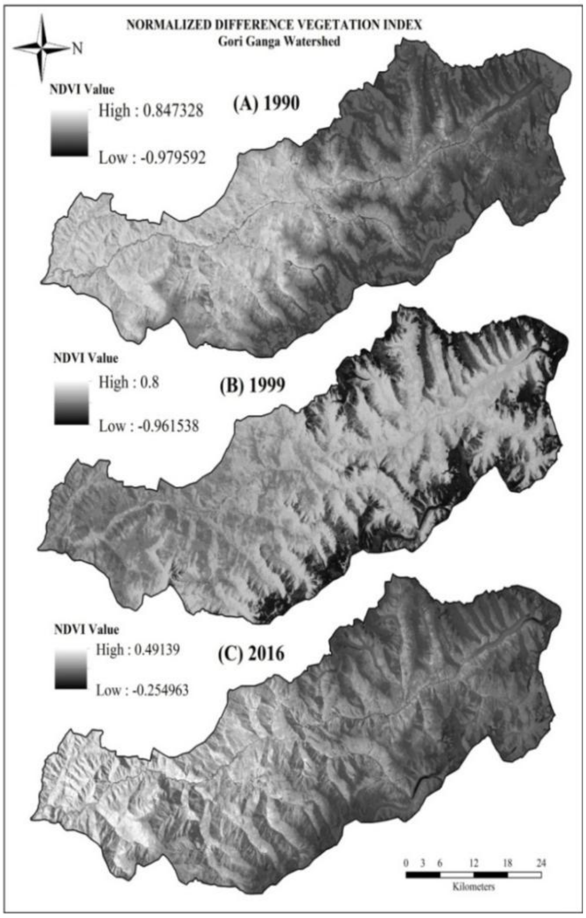

Figure 3: Geographical distribution NDVI values (>0.2) in different years in the Gori Ganga watershed in (A) 1990, (B) 1999 and (C) 2016 *(based on used NDVI techniques and Landsat-5 and 8, Satellite imageries).*

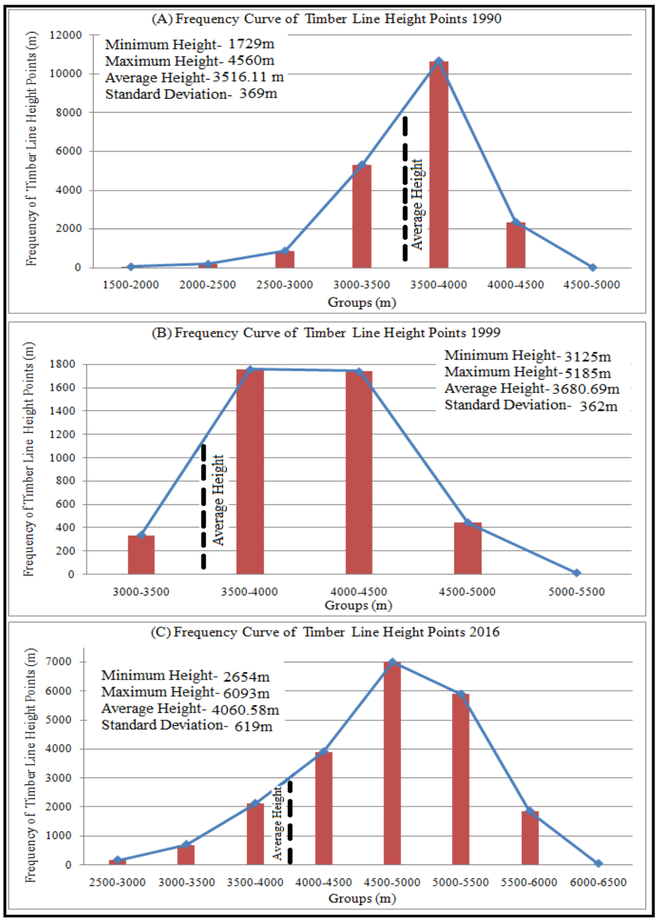

Figure 4: Timber line height frequency curve in the Gori Ganga watershed in (A) 1990, (B) 1999 and (C) 2016 *(based on Cartosat-1, Satellite image).*

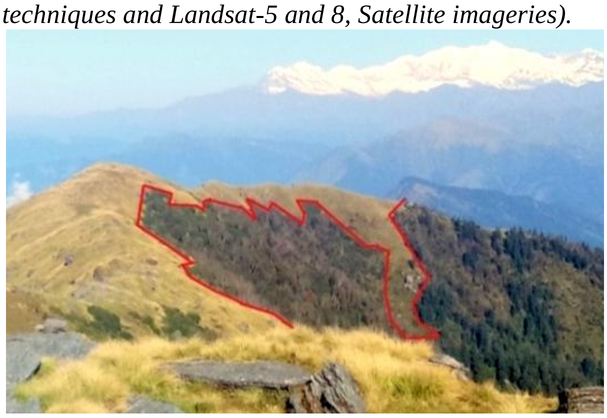

Plate 1: Timber line in the Chhipla Kedar Alpine region of the Gori Ganga watershed *(based on field visit October, 2017).*

Plate 2: Timber line in the Charthi alpine region of the Gori Ganga watershed *(based on field visit May, 2018).*

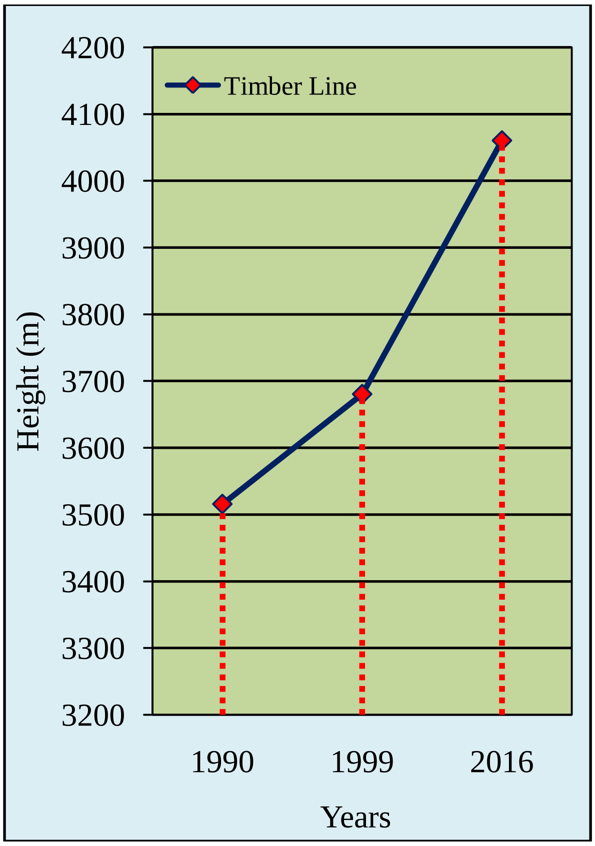

Figure 5: Average timber line altitude for the year 1990, 1999 and 2016 *(based on Cartosat-1, Satellite image).*

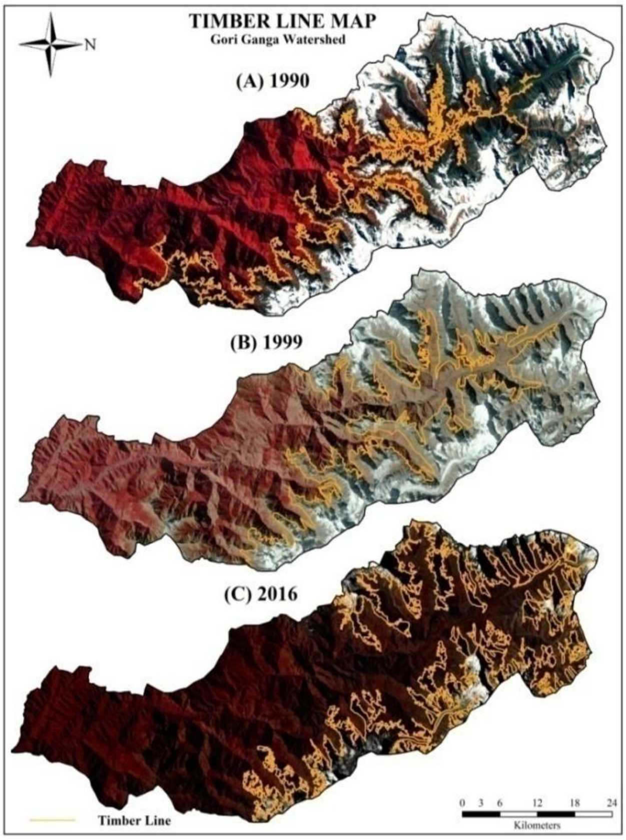

Figure 6: Geographic location of timber line based on NDVI values (>0.4) in different years in the Gori Ganga watershed (A) 1990, (B) 1999 and (C) 2016 *(based on NDVI techniques and Landsat-5 and 8, Satellite imageries).*

VII. CONCLUSION

The fundamental objective of this chapter is to determine the timber lines by using remote sensing and GIS techniques. For this study Landsat-5 (TM), Landsat-8 (OLI and TIRS) and Cartosat-1 satellite images of the years 1990, 1999 and 2016 were used. Based on this study the following may be concluded:

I. In 1990 the average height of timber line in the Gori Ganga watershed was about 3516.11 m sd ± 369 m which varies between 1729 m to 4560 m.

II. In 1999 the average height of timber line in the Gori Ganga watershed was about 3680.69 m sd ± 362 m which varies between 2654 m to 6093 m.

III. In 2016 the average height of timber line in the Gori Ganga watershed 2016 was about 4060.58 m sd ± 619 m which varies between 3125 m to 5185 m.

IV. This study has clearly determined that remote sensing and GIS application is determining the average height of timber lines.

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